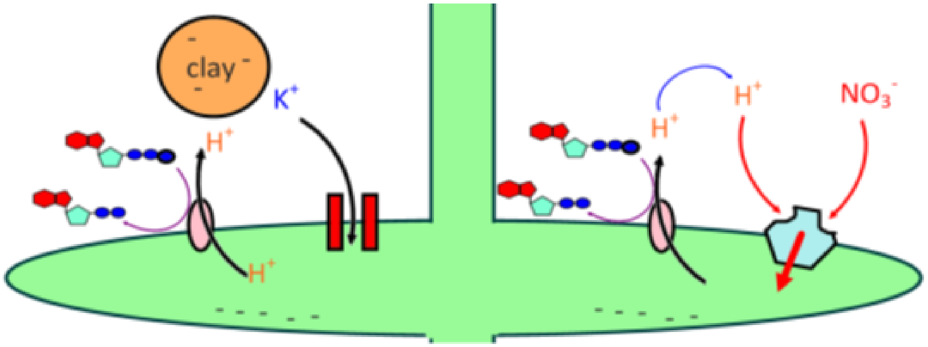
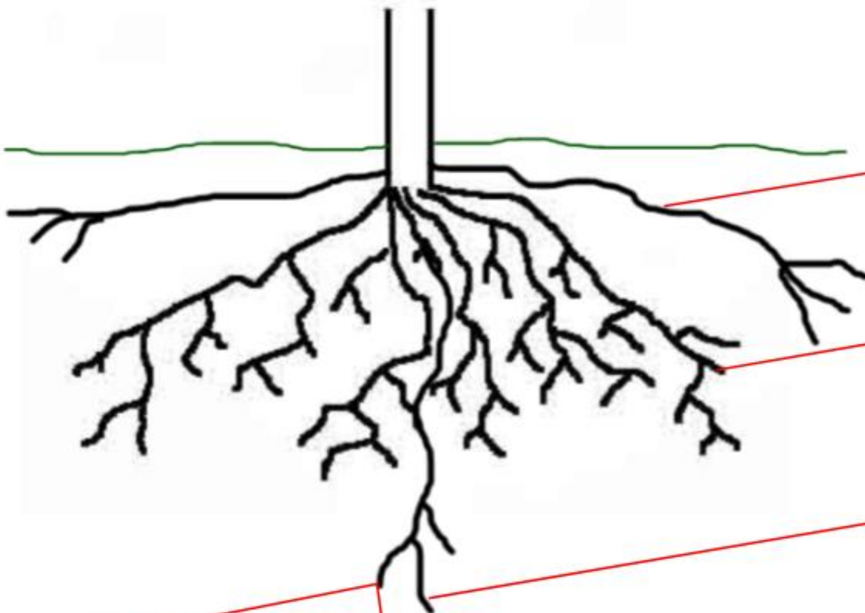


Transport in Angiospermophytes

Stephen Taylor
Bandung International School

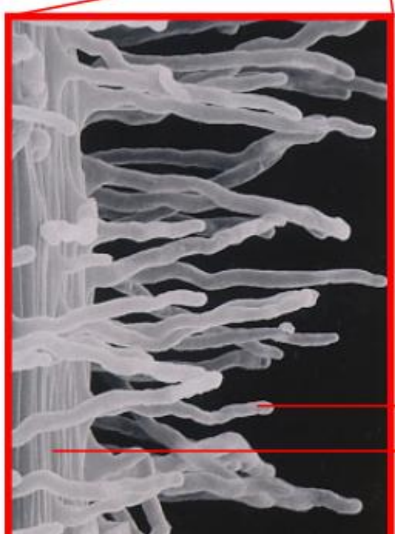
Root systems have a large surface area for anchorage, water and mineral ion uptake.



Shallow roots provide anchorage and collect surface water run-off or nutrients close to the soil surface

Branching root systems maximise surface area for absorption.

Dicot tap roots reach deeper into the soil to absorb water and mineral ions

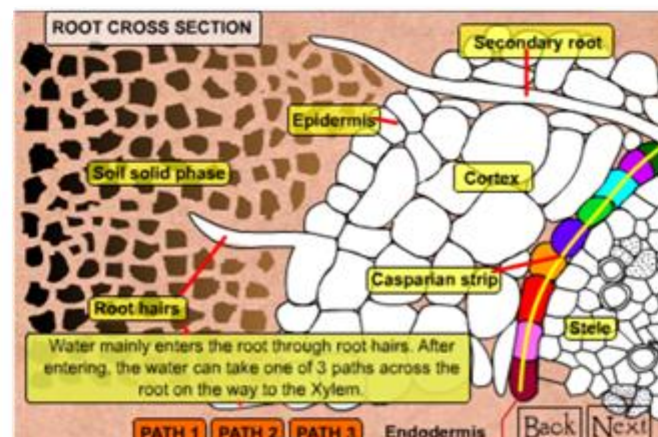


Root hairs increase the surface area for absorption further still.

Root hair

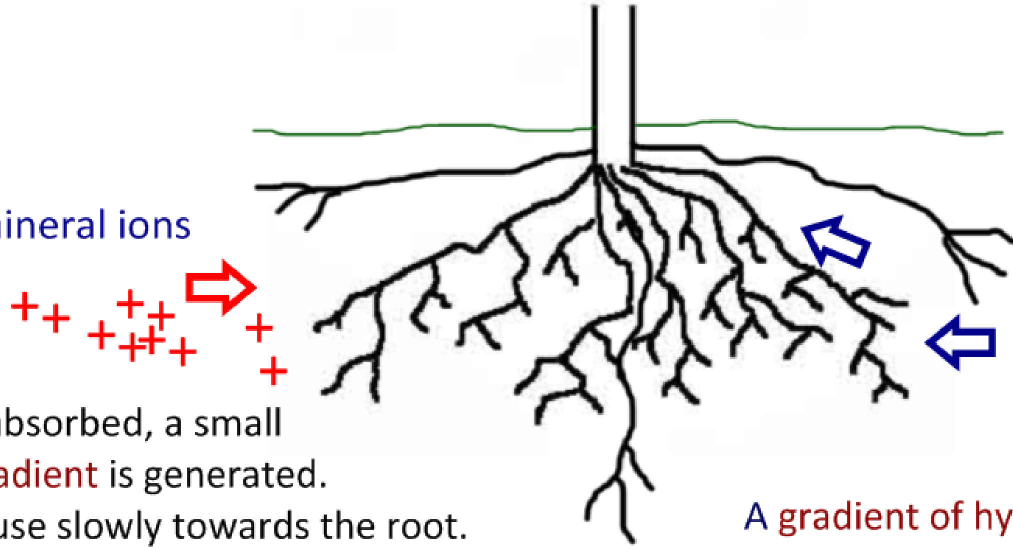
Root

To find out more about the pathways water and mineral ions take through the roots (not essential) view the animation.



http://plantandsoil.unl.edu/croptechnology2005/plant_phys/?what=animationList&informationModuleId=1057703469

Water and mineral ions must first travel to the roots before they are taken up.



1. Diffusion of mineral ions

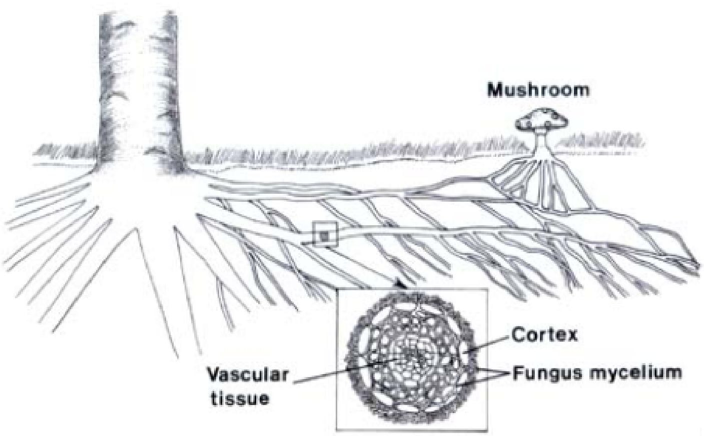
As minerals are absorbed, a small concentration gradient is generated.
Mineral ions diffuse slowly towards the root.

3. Mass flow

As water flows through the soil, it carried minerals with it in solution.

A gradient of hydrostatic pressure is generated by the uptake of water at the roots - water and solutes are literally (though slowly) 'sucked up'.

2. Fungal hyphae



A mutualistic relationship between some plants and fungi exists. Fungi produce a mycelium - a network in and around plant roots that helps increase the concentration of mineral ions (phosphates and nitrates).

In return, the fungi receive sugars from the plant.

http://www.apsnet.org/education/illustratedglossary/PhotosE-H/ectomycorrhiza.htm

Active transport (using energy) of <u>mineral ions</u> occurs at the root hairs.

Cations

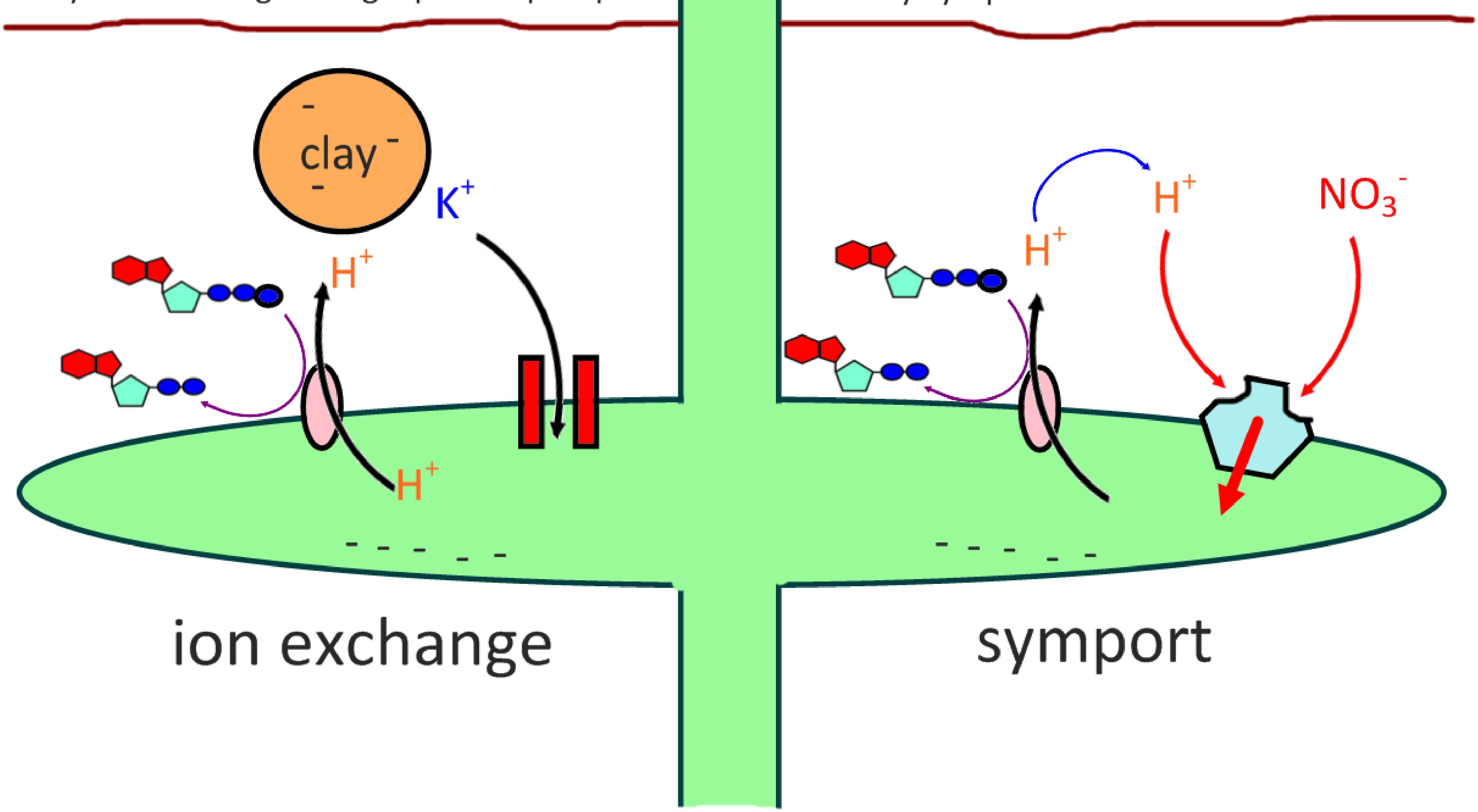
Ca^{2+} Positively charged: Ca^{2+}, K^+

By ion exchange using a proton pump

Anions

Negatively charged: NO_3^-

By symport with H^+ ions



Active transport of Cations: ION EXCHANGE

Clay particles in soil are negatively charged.

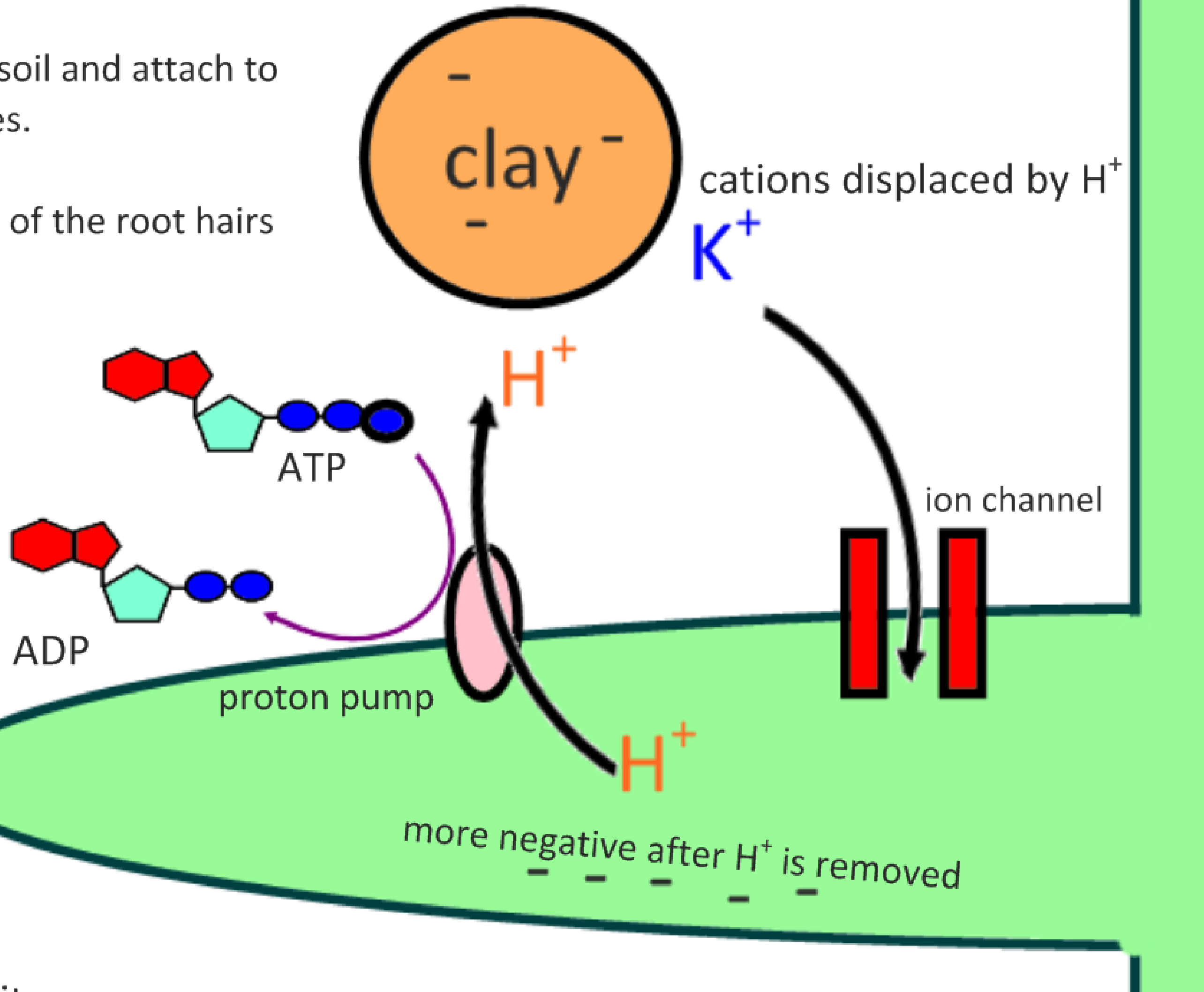
Cations are easily absorbed in soil and attach to the negatively charged particles.

A proton pump forces H^+ out of the root hairs and into the soil.

H^+ displaces cations (e.g K^+).

Cations are absorbed down the electrochemical gradient into the root hair.

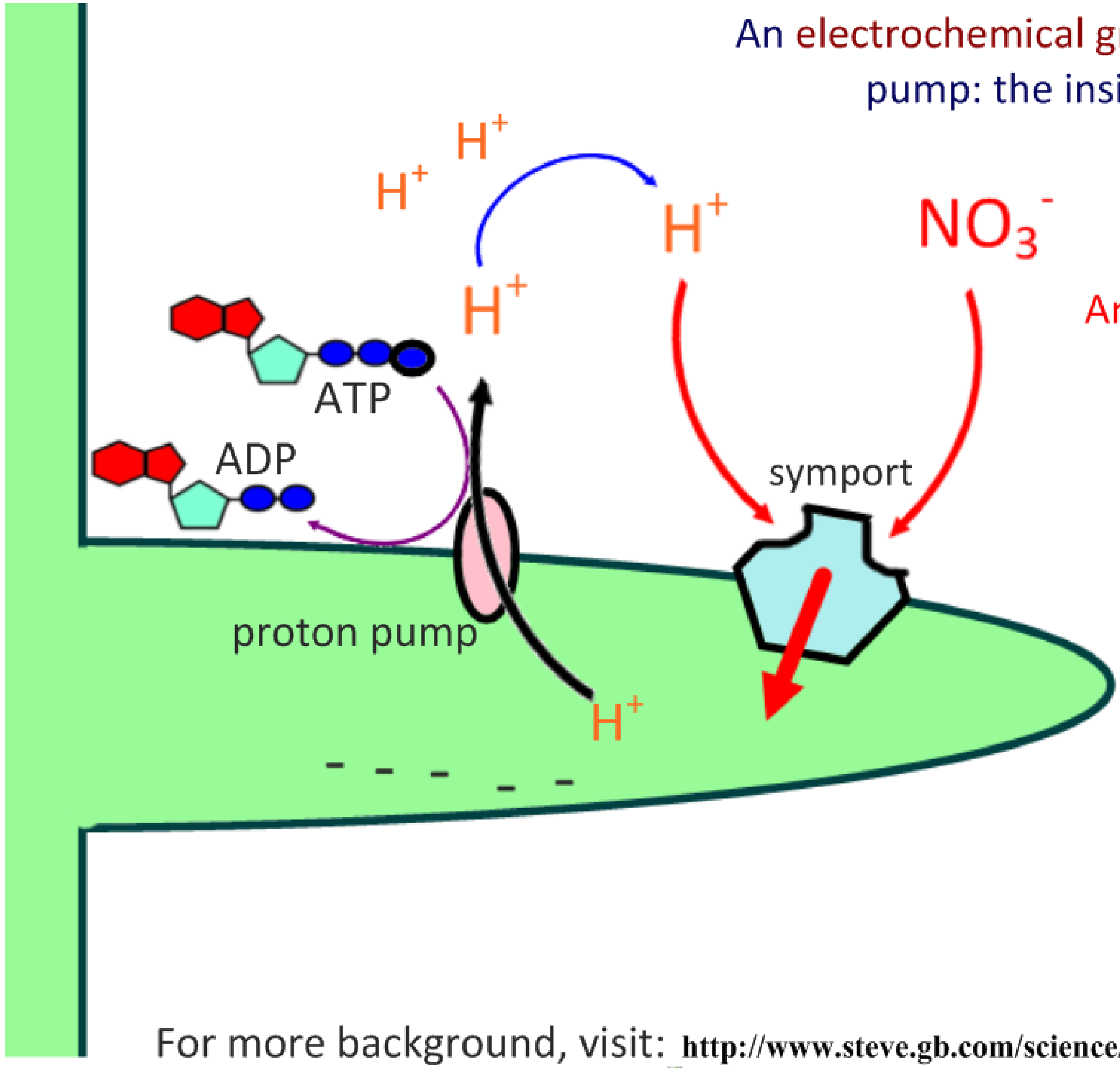
They pass through ion channels.



For more background, visit: http://www.steve.gb.com/science/plant_mineral_nutrition.html

Active transport of Anions: SYMPORT (remember, symport means 'pumped together')

An electrochemical gradient is generated by the proton pump: the inside of the root hair becomes more negative than the outside.



Anions (such as nitrates NO_3^-) can't diffuse down the electrochemical gradient as they are also negatively charged.

Instead, the energy from the H^+ gradient is used to actively transport the anions into the root hairs - this is called symport.

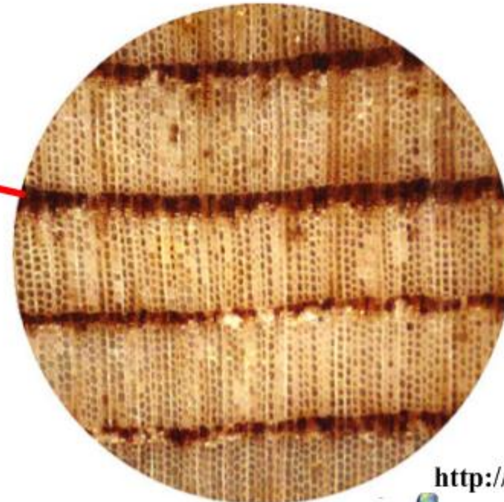
For more background, visit: http://www.steve.gb.com/science/plant_mineral_nutrition.html

Support of terrestrial plants: cell turgor, lignified xylem, thickened cellulose.

Cellulose in the cell wall is thicker relative to cell size near the outer edge of the stem.

http://web.mit.edu/dmse/csg/plantstemb.jpg

lignin



Xylem vessel carry water up the stem to the rest of the plant. For added suport, lignin rings are present periodically through the length of the stem. There are many xylem vessels, each lignified, so the summative support is great.

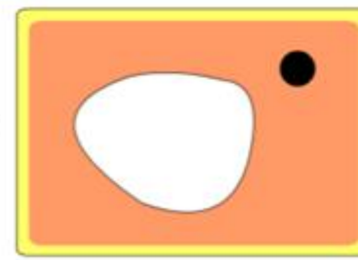
http://wayneswordpalomar.edu/images/rdwdxs1.jpg

Cell Turgor

Flaccid cell

Low hydrostatic pressure

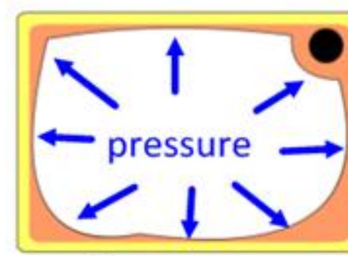
Wilting plant



Turgid cell

High hydrostatic pressure

Supported plant



http://www.kscience.co.uk/animations/turgor.swf

Transpiration is the loss of water from leaves and stems of plants.

Xylem vessels transport water through the plant.

Remember: water has cohesive properties die to H-bonds.

Water is heated in the mesophyll by sunlight and becomes vapour. This vapour transpires out of the stomata - pores in the leaf.

Loss of water generates negative pressure and a transpiration pull on water molecules in the xylem. More water is drawn into the leaf.

Cohesion between water molecules means that the transpiration pull has a knock-on effect through the plant. Higher rates of transpiration lead to a faster transpiration stream and higher rates of water uptake.

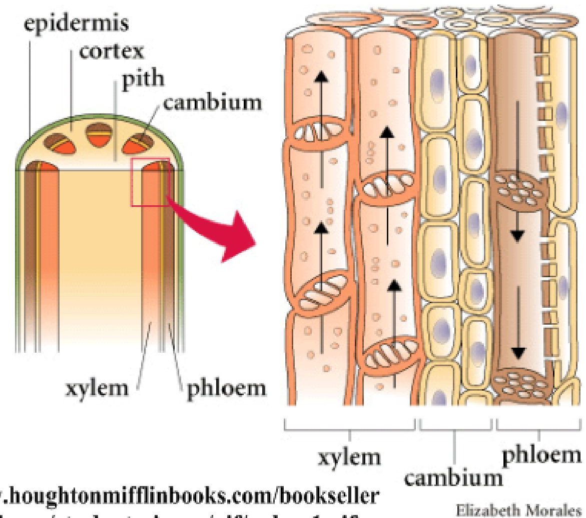
This theory is known as cohesion tension theory.

http://academic.kellogg.cc.mi.us/herbrandsonc/bio111/animations/0032.swf

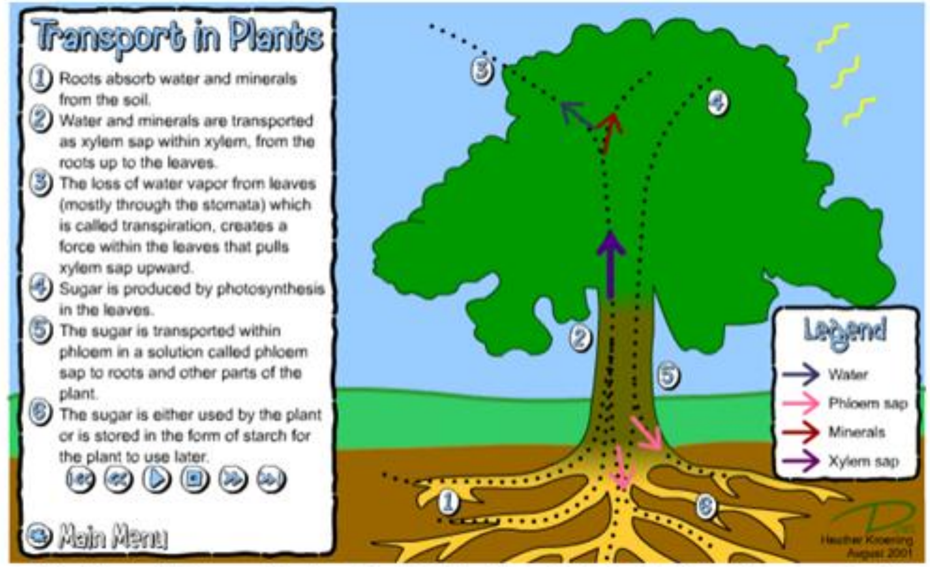
Remember: WXYlem
a
t
e
r

Phloem = Phood
(starch)

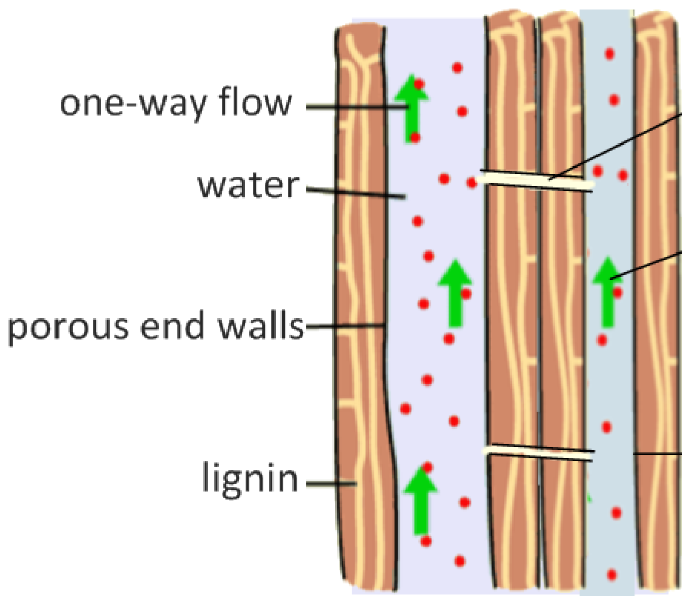
Transpiration flow occurs through the xylem



http://www.houghtonmifflinbooks.com/booksellers/press_release/studentscience/gif/xylem1.gif



http://www.biology.ualberta.ca/facilities/multimedia/uploads/alberta/transport.swf



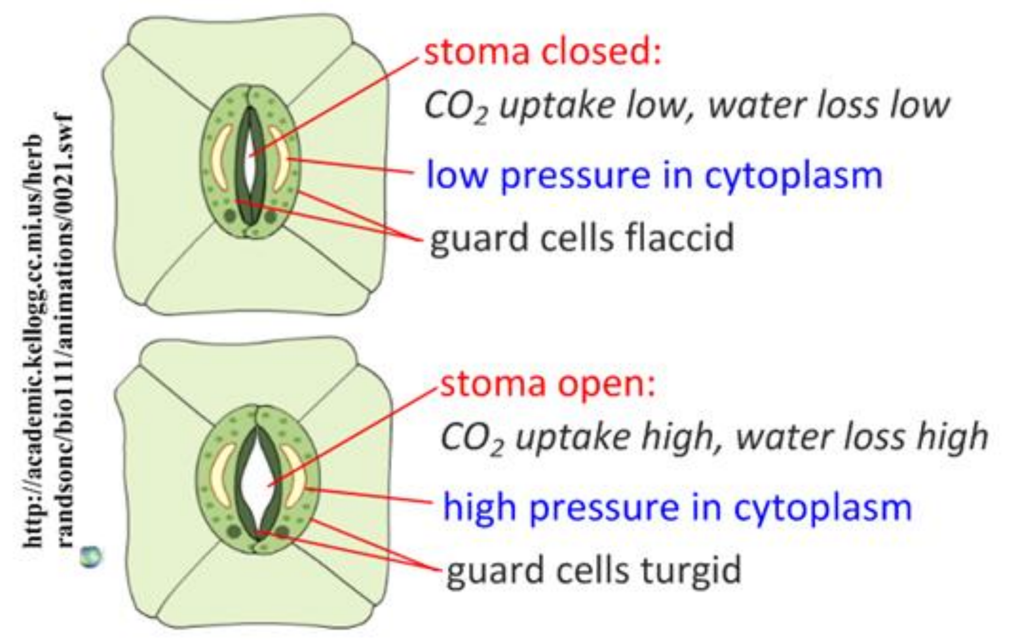
pits between xylem vessels allow sideways movement of water and ions

upwards movement through xylem is generated by the transpiration pull: cohesion between water molecules allows water to be 'sucked up'.

adhesion is the attraction between water molecules and the cellulose in the plant cell wall

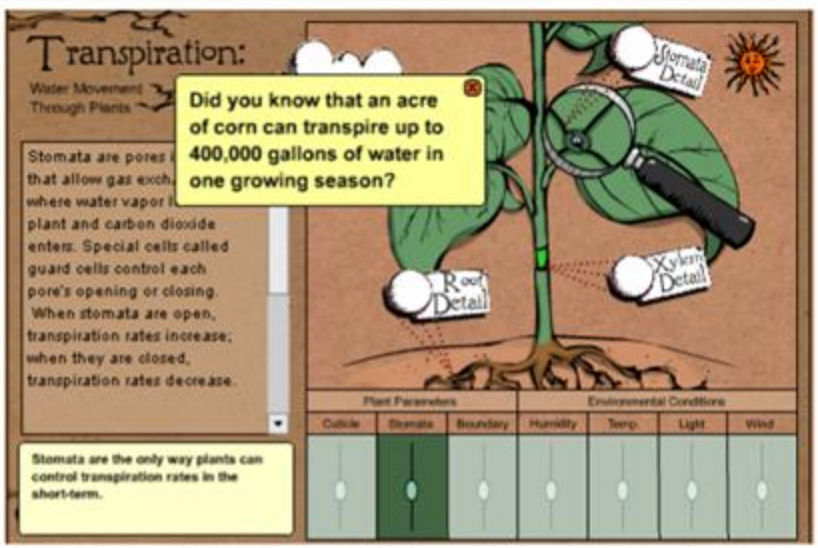
http://www.bbc.co.uk/schools/gcsebitesize/img/bixylemphloem.gif

Transpiration flow is controlled by the rate of water loss through stomata.



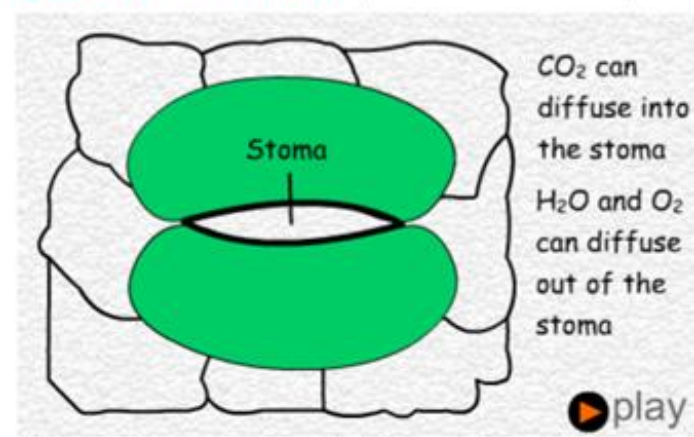
Stomata opening caused by:
- sunlight/ high photosynthesis
- reduced CO2 concentration

Stomata closing caused by:
- water shortage: the hormone absisic acid is produced, forcing closure to prevent dehydration.
- darkness



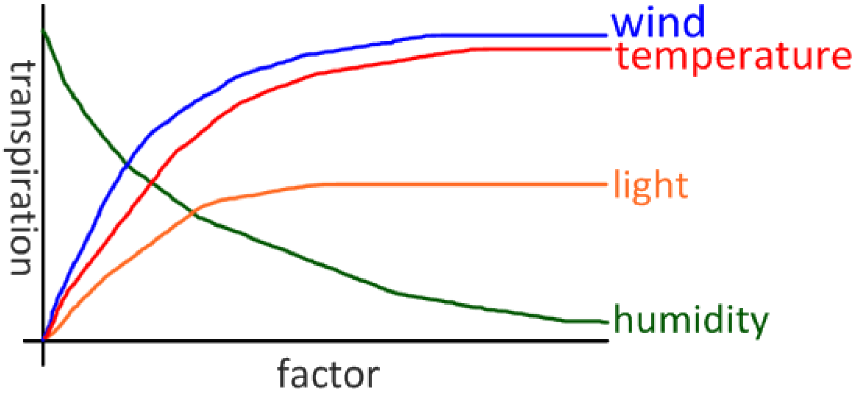
http://plantandsoil.unl.edu/croptechnology2005/pages/?what=animationList

The stoma is the hole! (*stomata* is the plural)

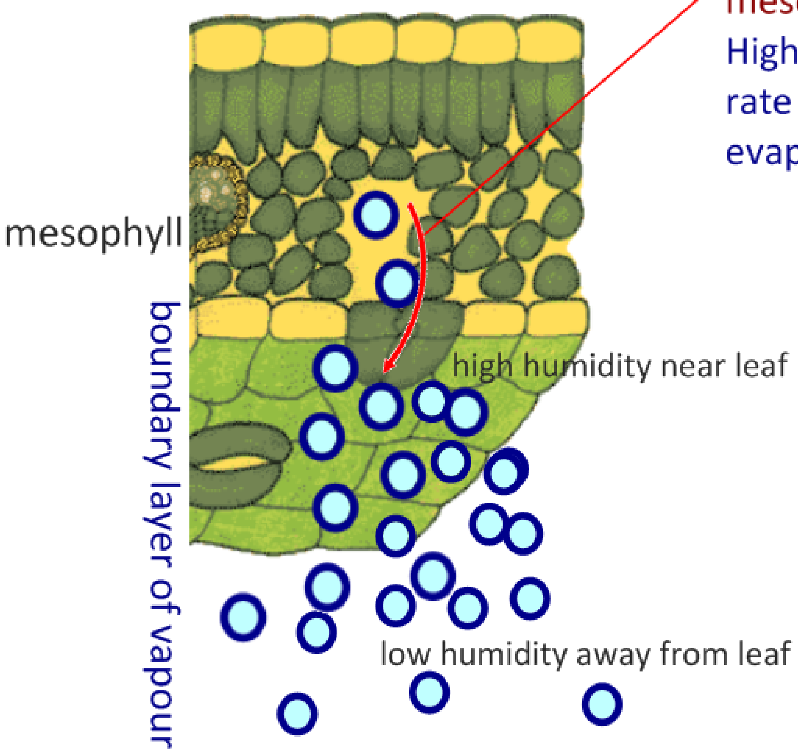


http://www.tvdsb.on.ca/westmin/science/sbioac/plants/stoma.htm

Abiotic factors affecting the rate of transpiration.



As photosynthesis is carried out, there is a greater demand for CO_2, so the stomata open in response to light to allow gas exchange. This also allows water to escape, and plants must maintain the balance betwen CO_2 uptake and water losses.



Heat and light cause water to become vapour in the spaces of the mesophyll. This escapes through open stomata.

Higher temperatures increase rate of transpiration by increasing rate of diffusion of water molecules, increasing rate of evaporation and increasing pressure within the cell.

Around the lead there is a boundary layer of water vapour. When air conditions are very humid, there is little difference between humidity inside and outside the leaf, so rate of transpiration is low.

Under dryer conditions, or with wind to blow away the boundary layer, the concentration graient of water vapour is greater, so transpiration increases.

Xerophytes: surving in dry conditions by reducing transpiration.

Where water is at a premium, plants need to adapt to reducing wastage through transpiration.

Life cycle adapations:

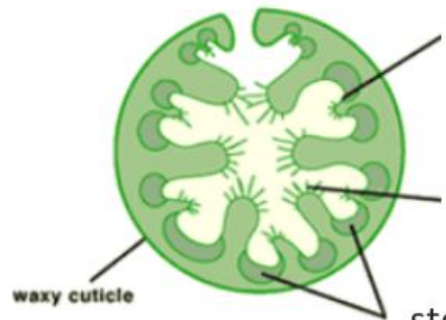
- perennial plants bloom in wet seasons
- dormant seeds can survive for many years until conditions are ideal for growth

Metabolic adaptations:

CAM plants (Crassulacean acid metabolism): CO_2 is absorbed at night and stored as a C_4 compound. During the day, photosynthesis can occur with the stomata closed by using these carbon stores.

Physical adapations:

- fewer leaves or stomata
- rolled leaves or spines
- stomata in pits with hairs
- deeper roots to reach water
- waxy cuticle reduces evaporation



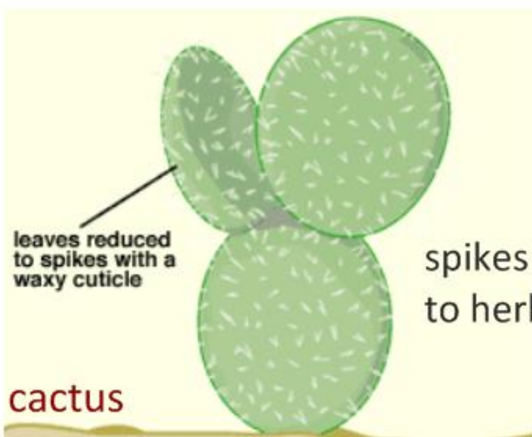
rolled leaf protects boundary layer from wind and reduces outward surface area

hairs trap a layer of water vapour

stomata in pits maintain boundary layer

marram grass

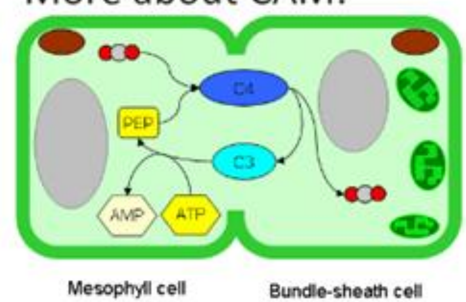
http://www.bbc.co.uk/scotland/education/bitesize/higher/img/biology/genetics_adaptation/transpiration



spikes prevent water loss to herbivores

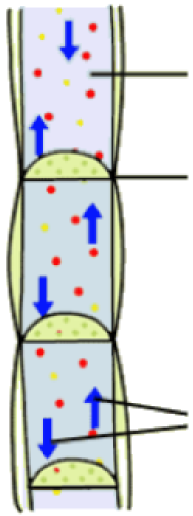
http://www.bbc.co.uk/scotland/education/bitesize/higher/img/biology/genetics_adaptation/transpiration

More about CAM:



http://www.steve.gb.com/science/photorespiration.html

Active translocation occurs in the phloem (moving food around)



http://www.bbc.co.uk/schools/gcsebitesize/img/bixylemphloem.gif

Plants produce their own carbohydrates in the leaves through photosynthesis. For the plant to grow and reproduce, this food needs to be transported (translocated) to the tissues that need it.

This is also true of proteins and amino acids.

The movement of phloem sap requires energy - it is an active process, so we call it active translocation.

Source = site of production or storage

Sink = destination/ site of use

Sugars

Source: *green leaves and stems*
storage tissues in seeds

Sinks: growing roots and stem
roots absorbing minerals
fruit production or other energy storage
flowering and reproduction

Amino Acids

Sources: *roots or tubers, rhizomes*
storage in germinating seeds

Sinks: *growing roots and stem*
developing leaves, fruits
flowering and reproduction

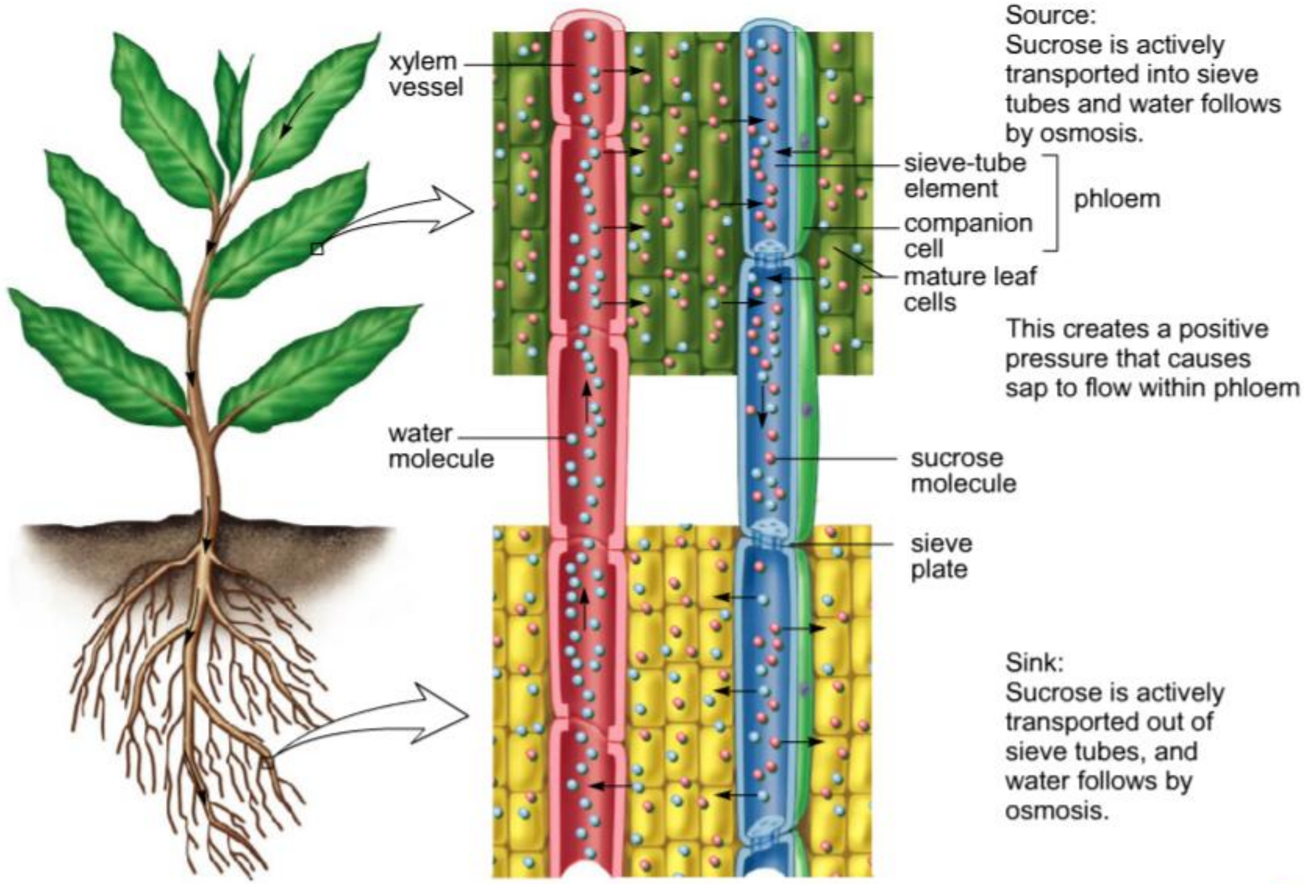


Figure 37.14
Pressure-flow model of phloem transport.

http://academic.kellogg.cc.mi.us/herbrandsonc/bio111/animations/0032.swf

For more help and animations, visit:

http://sciencevideos.wordpress.com